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Human settlements and sustainability: a crucial and open issue

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Abstract. The human habitation of the surface of the planet has led, especially since the mid-twentieth century, to an enormous increase in the built up area. This phenomenon concerns both the oldest industrialised countries, such as European Union and the United States, and the so-called emerging countries in Asia, Africa and Latin America. The urbanised built area has increased in different ways, but has led everywhere to the destruction of large portions of virgin soil, the loss of biodiversity in the number and type of species in fauna and flora, and often the total or partial impairment of ecosystem functions of enormous environmental value (such as the evapotransportive mechanisms of soil and vegetation). Although the curve of global population growth is slowing, the growth of urban areas continues to expand, even in countries which have long been industrialised, where the spread of building has given rise to cities dispersed over a territory so that there is no longer a recognisable clear division between the city and the countryside. In fact, contemporary cities are the main consumers of all environmental resources, from water to food, including energy and environmental stressors, and are responsible for 80% of CO₂ emissions into the atmosphere. The ecosystem surface required to sustain a large city on the planet today can be about 200 times larger than its physical size. The urban civilisation of the 21st century, which at a superficial glance may appear as a symbol of the human capacity to radically adapt and transform the natural habitat to its own needs, is also a witness to the unsustainability of the human footprint on earth. Radically rethinking cities and human settlements entails an equally radical rethinking of our economic and development model, but it is a necessary and strategic task if we really want to face the challenge of sustainability with appropriate instruments.

1 Phenomena of urban growth

Five years after the first Science and the Future conference, the problems concerning the relationship between human settlements and sustainability, despite the fact that international debate has intensified and expanded, appear to be unresolved. The growth trend of urban areas in size and number at the global level, already highlighted by studies and the projections of the United Nations in the past decade, is confirmed. Today, 55% of the world's population lives in cities and, while only 30% of the world's population lived in cities in 1950, about half of the population resided in urban areas by 2007. The current growth trend, in the absence of corrective measures, suggests that 66% of the world's population will live in urban areas in 2050 [1]. Currently the most urbanised regions on the planet are North America with 82% of the population living in urban areas, Latin America and the Caribbean with 81% of the population being urbanised, and Europe with 74%. The level of urbanisation in Asian countries is about 50%, and in Africa only 43% of the population lives in urban areas (WUP2018). Projections indicate that China, India and Nigeria were the countries with the highest urban population growth in the period 2018-2050 (about 35%).

Under these conditions, the challenge of sustainability is closely linked to the economic, social and environmental development of urban areas. It has been demonstrated that a country's economic growth depends heavily on the economy of its cities, with 80% of global GDP produced in urban areas [2].

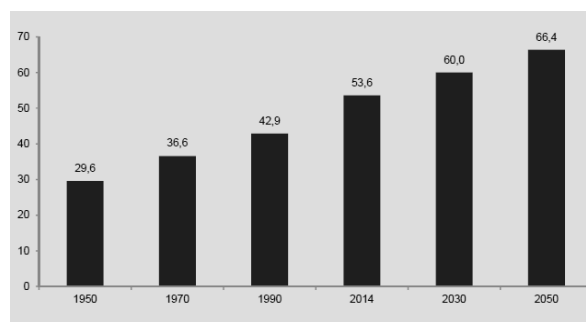


Fig. 1. Share of urban population. Percentage values. World. 1950-2050, UN data 2015, ISTAT 2017 processing.

It therefore seems clear that the growth phenomena of urbanised areas are closely related to the cycles of global and local economic development. The same globalisation of markets entails the transformation of cities into privileged locations for the location of

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financial and advanced tertiary companies, the main laboratories of innovation and experimentation of products and processes. The global market finds its fundamental spatial structure in the city of the third millennium. Like all phenomena of planetary economic globalisation, the dynamics of urbanisation are, however, contradictory. On the one hand cities can be considered the main generators of economic development and growth, but on the other hand their impact on the environment is very high. Even from a social point of view, costs are often very high, with negative consequences such as overcrowding, lack of adequate infrastructure, and especially in emerging countries, precarious housing (more than 1 billion people live in slums or in conditions of social and spatial segregation - UN 2016 data). As far as the European and Italian context is concerned, the growth in the size and number of urban areas is confirmed, even in the absence of demographic growth. This phenomenon, the so-called urban sprawl, which involves all the countries of the oldest urbanisation, is characterised by a disorderly and uncontrolled expansion towards the peripheral areas, and by a decrease in population density [3]. The main impacts of this type of urban growth from an environmental point of view are the consumption of free or agricultural land, the consequent loss of biodiversity (one of the most important indicators for sustainability), the loss of identity of places in the absence of any urban quality reference, the lack of a recognisable boundary between city and country, the need for road transport resulting in greater use of private vehicles, more traffic and pollution, and raising public spending on the provision of services and energy. According to Istat 2017 data, urban sprawl covers about 7% of the Italian surface, but this sprawl means that at least a quarter of the territory is involved in urban uses.

1.1 The situation of urban areas in Italy

The main Italian urban land together occupy an area of about 27,000 square km, 8.8% of the national surface. The largest area is Rome with 1.3% of the territory, followed by Turin, Bologna and Cagliari (about 0.8%), and Milan (about 0.6%). The group of medium-sized cities represents about a quarter of the total urbanised area, while the rest of the national territory (around 65%) belongs to small settlements. The data collected by Istat indicates that from 2001 to 2015 the growth of urban construction continued without interruption, and in particular among the 21 most important urban centres of the peninsula the average growth of building was around 8%, of which Turin grew by 11.6%. The inhabitants of the main urban areas in Italy account for 36.3% of the entire national population. The four main systems, Rome, Milan, Turin and Naples alone account for almost 20% of the entire Italian population. The average population density of the 21 most important urban centres at national level is 828 inhabitants per square kilometre compared to 201 for the rest of the national territory.

One of the most important consequences of the growth of urbanised areas is the consumption of free or agricultural land, which is replaced by an artificial surface cover linked to the dynamics of anthropic settlements (Land Cover, Directive 2007/2/EC). Since good quality soil hosts a large part of the biosphere and is able to carry out numerous ecosystem functions, and since the thickness of the soil present on the earth's crust is limited and takes a very long time to reform (about 200 years per 1 mm of thickness), it seems evident that it must be considered a very important non-renewable environmental resource. Artificial ground cover for the construction of buildings or roads generally involves soil sealing with the consequent serious impairment of ecosystem services that the free ground normally performs, and is therefore a very significant environmental cost (European Commission 2013).

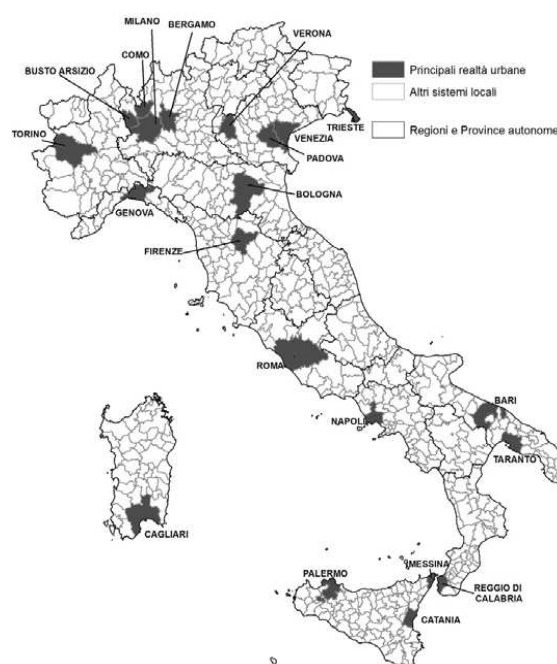


Fig. 2. Systems of the main urban realities in Italy. Consumption of soil and sealed surfaces. Source ISTAT 2017

The loss of permeability in particular is one of the main causes of soil degradation at a global level, increasing the risk of flooding, contributing to climate change, and threatening biodiversity and landscape quality. For these reasons, in 2015 the United Nations Global Agenda for Sustainable Development set a strategic objective for Sustainable Development (SDGs, UN Summit 2015) by 2030, that was to be integrated into national policies: soil protection through consumption not exceeding population growth, ensuring inclusive access to green spaces and areas, achieving the goal of a neutral land degradation worldwide. Despite the urgent need to take action to protect the soil on the European continent, some 1,000 square kilometres per year have been lost since the late 1990s [4]. The geographical and morphological peculiarities of Italy make it even more urgent to implement policies and strategic actions to protect the soil and the landscape. In

line with what happened in other industrialised countries, consolidated urban building in the main urban areas increased from 15.3% to 19.3% in Italy, in the twenty years from 1991-2011, with an average increase of % [5]. Land consumption appears to involve both central high population density areas and large sprawling peripheral areas. The areas most affected by these phenomena are the Po Valley (Turin hinterland, Milan conurbation, Bergamo Brescia axis), the Venetian-Emilian plain, the coastal systems from north to south, the metropolitan systems of Rome and Naples, those of northern Tuscany, and the areas around the main cities in the south such as Bari and Palermo, Catania and Messina.

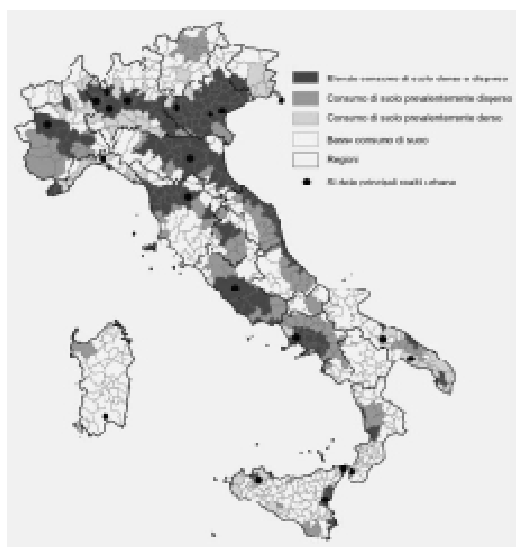


Fig. 3. Level of land use in local systems (2011), incidence of built-up areas, and population density outside urban areas, Sources ISTAT, 2011 Census

Of those Italian cities in which the consumption of land in relation to the total surface area of the urban area is more significant, we highlight Milan with about 40% of buildings and Naples with about 44%. Catania follows with 29%, Padua with 28.5%, and Rome with about 21%. Turin in 2011 was about 17%.

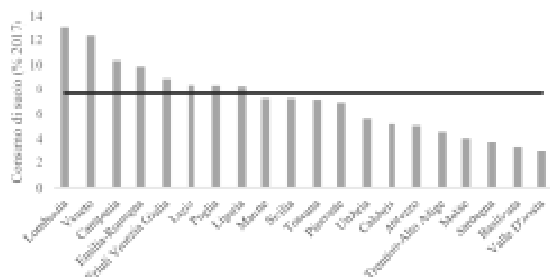


Fig. 4. Land use scenarios in Italy, 2017 - 2050. (Sources ISPRA 2018)

In general terms, the data provided by the SNPA (Sistema Nazionale per la Protezione dell'Ambiente - National System for the Protection of the Environment) cartography shows that at a national level we have gone from an artificial soil area of 2.7% in 1950 to 7.75% in

2017 (a growth of 180%), which means that 23,063 square km of Italian territory has been irreparably compromised, with a greater incidence in the areas of the Po Valley, along the Tuscan axis between Florence and Pisa, the plain areas of Lazio, Campania and Salento and along the coastal strips. Lombardy had the highest land consumption in 2017 [6] (310,000 hectares of artificial territory), followed by Veneto, Emilia Romagna and Piedmont. The regions with the lowest land consumption in 2017 were Liguria, Valle d'Aosta, Basilicata and Molise, with increases of less than 40 hectares.

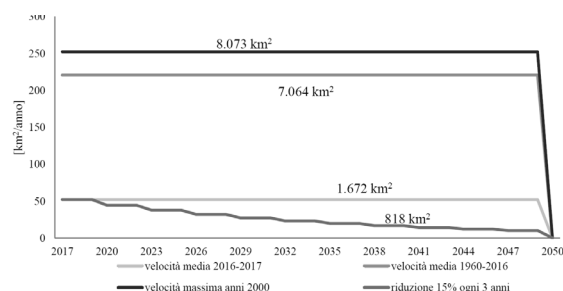


Fig. 5. Land consumption at regional level. The national average is in black. Sources ISPRA 2018

The dynamics of land consumption, increases and percentages, tend to confirm their correlation with the economic dynamics of the territories; in the presence of economic recovery and in the absence of stringent regulatory corrections, land consumption increases. In the absence of a framework regulatory instrument at national level, and in the presence of relatively heterogeneous regional rules, the scenarios currently opening up for land use in Italy (ISPRA Observatory) could have very different consequences. If the objective of achieving a zero increase in net land use in 2050 was pursued with conviction, this would mean 818 km² of new land lost between 2017 and 2050. If, on the other hand, the trend observed in 2017, in conditions of low economic growth, is confirmed, 1772 km² per year would be lost. In conditions of strong economic recovery, without strict regulation, land consumption values in the coming decades could continue and reach the 8073 square kilometers of land lost in 2050.

2 The energy impact of the Building sector

The growth of urban areas not only involves the loss of free soil and urban dispersion or concentration, but is inevitably accompanied by a growth in the volume and surface area of buildings in built-up areas, of truly impressive proportions. Over the last decade, in fact, more than 50 billion square metres of new concrete have been built globally, a trend that is not diminishing as urban growth forecasts for the next 40 years include 230 billion square metres of new buildings, equivalent to the construction of a city the size of Paris every week. The building sector [7] accounts for 36% of final energy consumption globally, the majority of this consumption (82%) is still met by the use of fossil fuels. According to data from the GABC Dossier 2016, buildings and

constructions are responsible for 39% of total CO₂ emissions. To meet the objectives of the Paris Climate Agreements of 2015, and contain the increase in global warming to 2°C in the century, the energy efficiency of buildings need to improve by 30% compared to 2015 levels by 2030. This means that from now on and in the next decade, zero-emission and near-zero energy buildings should become the global standard. The dossier highlights the rapid growth of construction on a global scale: without corrective measures, the surface area of buildings in the world will double by 2060.

Although the efficiency of the energy sector has improved in recent years, it is still not sufficient to reduce the increase in energy demand. CO₂ emissions have continued to grow by 1% per year since 2010, and more than four million deaths per year are attributable to diseases caused by pollution from buildings. High energy performance building and profoundly upgrading existing buildings could save about 91,000 TWh (330 exajoules) until 2060 (more than the final energy consumption of all the G20 countries in 2015), and using high-efficiency heating and cooling technologies would also cut energy consumption by a further 180 TWh (660 exajoules) in terms of global energy demand, which is equivalent to China's final energy consumption in the last ten years.

2.1 City cause and solution of the problem. Rethink the city, rethink the development model.

As we have seen, building stock is mainly concentrated in the cities, and today it represents a huge cost from an energy and environmental point of view, but it can also be considered an extraordinary resource, not only from a strictly construction point of view but in relation to the need to protect the agricultural soil and the landscape. Understanding this contradiction and overcoming it is one of the main technical (but also cultural and economic) challenges that awaits us in this century. If an ecosystem is a unit that includes all the organisms that live together in a given area and interact with the physical environment, forming a stable biotic structure within a closed cycle of matter and energy [8] [9], then the city can be considered an open thermodynamic system depending on the environment in which it is inserted, and where the energy comes mainly from fossil fuels. Current metropolitan areas are characterised by a continuous flow of unidirectional energy inwards, whose continuous increase makes the urban model structurally unstable and vulnerable. In order for the urban organism to increase its resilience, it is necessary for it to establish a "sustainable" relationship with its territory that reduces the input (material and energy) and output (entropy and waste) flows and in compliance with the time required for the exploitation of solar energy and natural cycle.

This implies a transformation of the urban metabolism from linear to circular. The close relationship between cities and energy consumption has historically conditioned the evolution or decline of important historical cities and has strongly affected their

different spatial configurations. In recent decades, experimentation via pilot programmes in several cities at European and international levels has shown the need to identify general indicators for the objective evaluation of the quality of settlements. The difficulty lies in understanding urban dynamics, which are by their nature complex, with disaggregated and partial indicators.

2.2 Buildings and energy consumption, reducing them is possible

There are many obstacles on the path to energy efficiency in buildings, the first being a lack of standards and common language. A uniformity of language is absolutely necessary in order for the construction industry to grow and respond to the climate challenge. Other sectors have developed and use common languages, such as ICT communication protocols, and this is their strength. Almost 70% of the world's building consumption is not currently covered by mandatory codes and standards. Two thirds of countries do not have energy standards for the construction of new buildings. This means that in the next 40 years, 100 billion cubic metres of new buildings (of the 235 planned) will not have any kind of mandatory energy code to comply with. In Europe, all new buildings from 2021 will have to have energy consumption "close to zero", they will have to be built as 10 times less energy-intensive than the average of the buildings in which we live today. An Italian study on residential energy consumption in the period 1970-2005 [10] has shown that while average consumption per home has decreased (as a result of tax exemption policies), overall residential energy consumption has increased, with an average annual increase of 1.3%. It can be deduced that in order to achieve significant energy savings, it is necessary to go beyond the scale of the single housing unit and the single building to consider all the buildings, the urban layout and the most efficient technological solutions on the urban scale. Since cities are mostly made up of buildings built in the second half of the twentieth century, however, and are inadequate and inefficient from an energy point of view, the redevelopment of the existing housing stock, which must be consistent with the European objective that provide for an 80% reduction by 2050 in carbon dioxide emissions, is one of the most important issues from the point of view of sustainability. In addition to the climate objectives, this should increase the energy security of our continent (*Deep renovation of buildings*, Report Ecofys, 2014). Currently, an area equal to 1% of the total building is redeveloped each year, with energy improvements of 15-25%, generally in individual apartments. This is a positive result, but it is completely inadequate in relation to the EU's decarbonisation objectives. The new phase, however, requires an acceleration of both the number of interventions, which will more than double, and their impact: individual measures (windows, boiler, insulation, etc.) will have to change to "deep renovation", the upgrading of entire buildings, with savings in the order of 60-80%. New construction methods, the use of high-performance

technologies and materials and the introduction of specific financing methods could create an environment that offers unexpected opportunities. Given the deep crisis in the construction sector, this development could be a great opportunity for its relaunch. As the utilities have done, the construction world will have to rethink itself. Companies that are the first to do so will be able to establish themselves on the market. We must therefore take a qualitative leap forward. The renovation of individual apartments in multi-storey buildings must be reduced and incentives for the redevelopment of entire buildings or neighbourhoods must be increased. An interesting example is the Netherlands, where in recent years an ambitious energy requalification programme (Platform 31) has been developed, using easily installable industrialised prefabricated elements that allow work to be carried out on 2-3 storey buildings in just fifteen days [11]. A thousand renovations are underway as part of an extensive government programme to upgrade 111,000 apartments in social housing. The refinement of these methods of intervention has enabled a 40% reduction in costs in three years and a change from halving consumption to the concept of "net zero energy", which is obtained by cutting the demand for air conditioning by 70% and meeting the remaining demand with renewables.

3 Conclusions

Given the impact of urbanisation on a global and local level, the environmental and energy requalification of cities should be considered one of the main strategic actions to achieve our model sustainable development, from both a resource perspective (environmental and energy), and a social perspective (equity and inclusiveness). Sustainability on an urban scale should be pursued above all through interventions aimed at reunifying peripheral and marginal areas, through redensification actions that favour a typological and functional mix and collective mobility, and the recovery of disused areas implementing urban greenery according to the principles of urban ecology. In terms of energy, on the other hand, the current policies of tax exemption for measures to improve the energy performance of buildings are not enough to achieve an effective reduction in consumption and to reduce greenhouse gas emissions, and it is necessary to identify the most efficient technological solutions at the urban building scale. Energy and environmental actions and strategies are needed to promote urban self-sufficiency, reducing the flow of materials and energy in and out, and of emissions and wastewater, bringing the functioning of the urban metabolism closer to that of natural ecosystems. The integration and use of renewable energy sources must be encouraged by promoting the creation of smart grids, in close relation to the specific functional needs and the different environmental conditions of the city (smart cities). It is also necessary to integrate the positive ideas coming from participatory and "bottom-up" cooperative experiences of changing lifestyles, in relation to more sustainable housing and urban models,

into global and local policies. The challenge of sustainability implies a radical rethinking of our development model and lifestyle: as already clearly identified in the first "Limits to Growth" report of 1972, the assumptions on which they are based, those of unlimited growth, are conceptually and scientifically wrong. Natural resources are not interchangeable and are limited. To achieve sustainable development, it is not enough to estimate the value of natural resources monetarily and to internalise the environmental costs and benefits in economic accounts. Sustainability requires a new paradigm of economy and development, based on the limits of the biosphere bound to the Second Principle of Thermodynamics, limits that are ever closer and cannot be circumvented.

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